CLAIMS

1. A power system comprising:

a driveshaft;

means for extracting energy from a hot gas stream to power said driveshaft;

an evaporative duplex counterheat exchanger including a first heat exchanger having a first main flow channel and counterheat channel joined in flow communication therewith, a second heat exchanger having a second main flow channel adjacent said counterheat channel, and means for injecting an evaporative fluid into said counterheat channel; and

said duplex exchanger being joined in flow communication with said energy extracting means.

2. A system according to claim 1 wherein:

said first and second main flow channels are disposed in concurrent and parallel flow; and

said counterheat channel is disposed in opposition to both said first and second main flow channels for evaporatively cooling flow channeled therethrough.

3. A system according to claim 1 wherein:

said first and second main flow channels are independent from each other and from said counterheat channels for maintaining dry flow channeled therethrough; and

said counterheat channel is disposed between said first and second main flow channels for wetting flow discharged from said first main flow channel to evaporatively cool said first and second main flow channels.

4. A system according to claim 3 wherein said counterheat channel is disposed in crossflow with said first and second main flow channels.

5. A system according to claim 3 wherein counterheat channel is disposed in counterflow with said first and second main flow channels.

6. A system according to claim 3 wherein said counterheat channel extends in common between said first and second main flow channels in common flow communication with a discharge end of said first main flow channel.

7. A system according to claim 6 wherein said first main flow channel includes a series of perforations for providing intermediate flow communication with said counterheat channel.

8. A system according to claim 3 wherein said counterheat channel includes independent portions adjacent said first and second main flow channels, and commonly joined in split flow communication with a discharge end of said first main flow channel.

9. A system according to claim 8 wherein said counterheat channel includes a first portion disposed in counterflow with said first main flow channel, and a second portion disposed in counterflow with said second main flow channel.

10. A system according to claim 3 wherein:

said energy extracting means includes an outlet for discharging said gas stream as exhaust flow; and

said duplex exchanger is disposed in flow communication with said exhaust outlet for receiving said exhaust flow therefrom.

11. A system according to claim 10 wherein said second main flow channel of said duplex exchanger is disposed in flow communication with said exhaust outlet.

12. A system according to claim 11 wherein:

said energy extracting means further includes an inlet for receiving said hot gas stream as inlet flow; and

said inlet is disposed in flow communication with said counterheat channel of said duplex exchanger for receiving flow therefrom.

13. A system according to claim 12 further comprising:

a compressor for pressurizing air and discharging said pressurized air from an outlet thereof; and

said first main flow channel of said duplex exchanger is disposed in flow communication with said compressor for receiving hot pressurized air therefrom.

14. A system according to claim 13 wherein said evaporative fluid is water for adding water vapor to said pressurized air in said counterheat channel to increase mass of said hot gas stream channeled to said energy extracting means.

15. A system according to claim 13 wherein said evaporative fluid is fuel for adding fuel vapor to said pressurized air in said counterheat channel to increase mass of said hot gas stream channeled to said energy extracting means

16. A system according to claim 13 further comprising a combustor disposed in flow communication between said counterheat channel of said duplex exchanger and said inlet of said energy extracting means.

17. A system according to claim 16 further comprising means for injecting fuel into said combustor for combustion with said pressurized air received from said duplex exchanger.

18. A system according to claim 17 wherein said energy extracting means comprises a turbine joined to said driveshaft.

19. A system according to claim 13 further comprising an afterburner disposed in flow communication between said outlet of said energy extracting means and said second main flow channel of said duplex exchanger for providing hot combustion gases to said duplex exchanger.

20. A system according to claim 19 wherein said energy extracting means comprises a reciprocating piston in a corresponding expansion cylinder and joined to said driveshaft.

21. A system according to claim 13 wherein:

said evaporative duplex counterheat exchanger defines a first duplex exchanger;

said compressor includes an inlet for receiving air for compression; and

further comprising a second evaporative duplex counterheat exchanger joined in flow communication with said compressor inlet for providing precooled air thereto.

22. A system according to claim 21 wherein second duplex exchanger includes a corresponding second main flow channel disposed in flow communication with said compressor inlet for providing said precooled thereto by evaporative cooling from a corresponding first main flow channel and counterheat channel thereof.

23. A system according to claim 13 further comprising:

first and second stage compressors disposed in serial flow communication with said evaporative duplex counterheat exchanger as a first duplex exchanger;

a second evaporative duplex counterheat exchanger disposed in flow communication with said first stage compressor for precooling air thereto; and

a third evaporative duplex counterheat exchanger disposed in flow communication between said first and second stage compressors for interstage cooling said pressurized air therebetween.

24. A system according to claim 23 wherein:

said second duplex exchanger includes a corresponding second main flow channel joined in flow communication with said first stage compressor;

said third duplex exchanger includes a corresponding second main flow channel joined in flow communication between said first and second stage compressors; and

both said second and third duplex exchangers further include respective first main flow channels and counterheat channels for evaporatively cooling flow channeled through said respective second main flow channels thereof.

25. A system according to claim 24 further comprising means for channeling ambient air through said first main flow channels of said second and third duplex exchangers.

26. A system according to claim 24 further comprising:

means for channeling air through said first main flow channel of said second duplex exchanger; and

means for channeling fuel through said first main flow channel of said third duplex exchanger.

27. A system according to claim 24 further comprising a dehumidifier disposed in flow communication with said first main flow channels of said second and third duplex exchangers for drying air channeled thereto.

28. A system according to claim 27 wherein said dehumidifier comprises a desiccant wheel.

29. A system according to claim 28 further comprising a heater joined in flow communication between said energy extracting means and said dehumidifier for providing hot reactivation air therefor.

30. A system according to claim 24 further comprising a heater joined in flow communication between said second stage compressor and said third duplex exchanger for recirculating and heating said evaporative fluid from said first duplex exchanger using heat from said pressurized air flowing between said second stage compressor and said third duplex exchanger.

31. A system according to claim 24 further comprising:

a humidifier disposed in flow communication with said second main flow channel of said first duplex exchanger for receiving hot exhaust flow therefrom;

means for injecting salt water into said humidifier;

a fourth evaporative duplex counterheat exchanger disposed in flow communication with said humidifier for receiving a hot humidified stream therefrom for cooling thereof; and

a condenser disposed in flow communication with said fourth duplex exchanger for condensing desalinated water from said humidified stream.

32. A system according to claim 24 further comprising:

a fourth evaporative duplex counterheat exchanger disposed in flow communication with said compressor in parallel flow with said first duplex exchanger for receiving a portion of said pressurized air from said compressor; and

said fourth duplex exchanger being further disposed in flow communication with said energy extracting means for providing said pressurized air portion to said energy extracting means as cooled dry air.

33. A system according to claim 32 wherein said energy extracting means comprises a turbine joined to said driveshaft and including rotor blades joined in flow communication with said fourth duplex exchanger for cooling thereof.

34. A system according to claim 33 wherein:

said turbine 3 further includes nozzle vanes disposed upstream of said rotor blades; and

said counterheat channel of said first duplex exchanger is additionally joined in flow communication with said vanes for providing humidified cooling air thereto.

35. A system according to claim 11 wherein:

said energy extracting means comprises a steam turbine having a inlet for receiving hot pressurized steam, and an outlet for discharging steam to said second main flow channel of said duplex exchanger; and

said duplex exchanger comprises a condenser for cooling and condensing water from said steam.

36. A system according to claim 35 further comprising:

a steam generator disposed in flow communication with said turbine for providing said steam thereto; and

a recuperator disposed in flow communication with both said steam generator and said duplex exchanger for heating said condensed water from said duplex exchanger prior to delivery to said steam generator using heat recovered from air channeled through said first main flow channel and said counterheat channel of said duplex exchanger.

37. A system according to claim 11 wherein:

said energy extracting means comprises a turbine joined to said driveshaft;

said second main flow channel of said duplex exchanger includes an inlet disposed in flow

communication with said turbine outlet; and

further comprising an exhaust compressor disposed in flow communication with said second main flow channel of said duplex exchanger for sucking flow therefrom.

38. A system according to claim 37 wherein said counterheat channel of said duplex exchanger is disposed in flow communication with an inlet of said turbine.

39. A system according to claim 38 further comprising a combustor disposed in flow communication between said counterheat channel of said duplex exchanger and said turbine inlet.

40. A system according to claim 39 further comprising:

an air compressor disposed in flow communication with said first main flow channel of said duplex exchanger for providing pressurized air thereto; and

a second evaporative duplex counterheat exchanger disposed in flow communication with said air compressor for providing precooled dry air thereto.

41. A system according to claim 39 further comprising a second evaporative duplex counterheat exchanger disposed in flow communication between said exhaust compressor and said combustor for providing wet air to said combustor.

42. A system according to claim 41 wherein:

said counterheat channel of said second duplex exchanger is disposed in flow communication with said combustor for channeling combustion air thereto; and

said injecting means are configured for injecting both water and fuel into said counterheat channel for evaporation in said combustion air.

43. A method of using said power system according to claim 3 comprising:

channeling said hot gas stream through said energy extracting means for extracting energy therefrom to power said driveshaft;

discharging said gas stream from said energy extracting means as exhaust flow;

channeling said exhaust flow through said second main flow channel of said duplex exchanger;

channeling air through said first main flow channel; and

injecting said evaporative fluid into said counterheat channel for saturating said air flowing therethrough and cooling both said exhaust flow in said second main flow channel, and said air in said first main flow channel below the wet bulb temperature thereof.

44. A method according to claim 43 further comprising discharging said saturated air from said counterheat channel into said energy extracting means for adding mass to said hot gas stream.

45. A method according to claim 44 wherein said energy extracting means comprises a turbine and further comprising:

compressing air to form hot pressurized air;

channeling said hot pressurized air through said first main flow channel of said duplex exchanger for being saturated in said counterheat channel; and

mixing fuel with said saturated air discharged from said counterheat channel and burning the mixture thereof to produce said hot gas stream channeled through said turbine for energy extraction therefrom.

46. A method according to claim 45 wherein said evaporative fluid is water for adding water vapor to said pressurized air in said counterheat channel to increase mass of said hot gas stream channeled to said energy extracting means.

47. A method according to claim 45 wherein said evaporative fluid is fuel for adding fuel vapor to said pressurized air in said counterheat channel to increase mass of said hot gas stream channeled to said energy extracting means.

48. A method according to claim 45 wherein:

said evaporative duplex counterheat exchanger defines a first duplex exchanger; and

said air, prior to compression, is precooled in a second evaporative duplex counterheat exchanger through a corresponding second main flow channel thereof.

49. A method according to claim 48 further comprising compressing said air in two stages, using said second duplex exchanger to precool air delivered to said first stage, and using a third evaporative duplex counterheat exchanger to interstage cool said pressurized air between said two stages through a corresponding second main flow channel thereof.

50. A method according to claim 49 wherein:

both said second and third duplex exchangers further include corresponding first main flow channels and counterheat channels in respective flow communication therewith; and

further comprising channeling air or fuel through said first main flow channels of said second and third duplex exchangers.

51. A method according to claim 50 wherein said evaporated fluid is water injected into said counterheat channels of said first, second, and third duplex exchangers.

52. A method according to claim 51 further comprising dehumidifying air channeled to said first main flow channels of both said second and third duplex exchangers.

53. A method according to claim 51 further comprising heating and recirculating said evaporative fluid water from said first duplex exchanger using heat from said pressurized air channeled to said third duplex exchanger.

54. A method according to claim 49 further comprising:

humidifying exhaust flow from said second main flow channel of said first duplex exchanger using salt water;

channeling said humidified exhaust flow from said first duplex exchanger through a corresponding second main flow channel of a fourth evaporative duplex counterheat exchanger for cooling said exhaust flow and condensing desalinated water therefrom.

55. A method according to claim 49 further comprising:

splitting in first and second portions said pressurized air after compression in said two stages;

channeling said first split air portion to said first duplex exchanger;

channeling said second split air portion to a corresponding second main flow channel of a fourth evaporative duplex counterheat exchanger for cooling therein; and

channeling said cooled second split air portion from said fourth duplex exchanger to said turbine.

56. A method according to claim 55 wherein:

said turbine includes nozzle vanes disposed upstream from rotor blades;

said cooled second split air portion is channeled to said rotor blades for cooling thereof; and

further comprising splitting humidified air from said counterheat channel of said first duplex exchanger in one portion for burning, and in another parallel flow portion channeled to said nozzle vanes for cooling thereof.

57. A method according to claim 44 wherein said energy extracting means comprises a reciprocating piston joined to said driveshaft.

58. A method according to claim 44 wherein:

said energy extracting means comprises a steam turbine; and

further comprising channeling hot pressurized steam to said turbine, with exhaust flow therefrom being channeled to said second main flow channel of said duplex exchanger for condensing water therefrom.

59. A method according to claim 44 wherein:

said energy extracting means comprises a turbine joined to said driveshaft; and

further comprising sucking flow from said second main flow channel of said duplex exchanger for compression thereof to atmospheric pressure.